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Procedia - Social and Behavioral Sciences 222 (2016) 83 – 92

Procedia
Social and Behavioral Sciences

ASLI QoL2015, Annual Serial Landmark International Conferences on Quality of Life
ASEAN-Turkey ASLI QoL2015
AicQoL2015Jakarta, Indonesia. AMER International Conference on Quality of Life
The Akmani Hotel, Jakarta, Indonesia, 25-27 April 2015
"Quality of Life in the Built & Natural Environment 3"

Industrialised Building System Modular System (IBSMS) Organisational Readiness Framework

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Abstract

Off-site prefabrication and modern method of construction (MMC) has proven to promote sustainability in the construction industry that improve human sociology, foster economic development and environment stability. Modular construction is an innovation in the Malaysian construction industry. This paper discusses the study on IBSMS Organisational Readiness Framework for modular construction implementation through IBS approach in Malaysia. The study explored and identified the readiness elements and criteria as the main components of the framework. Through the framework, organisations that execute modular construction or IBSMS will be well prepared and ready to execute modular construction efficiently, thus improving Malaysian construction industry.

Peer-review under responsibility of AMER (Association of Malaysian Environment-Behaviour Researchers) and cE-Bs (Centre for Environment- Behaviour Studies, Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Malaysia.

Keywords: Industrialised Building System (IBS); Industrialised Building System Modular System (IBSMS); modular construction

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Peer-review under responsibility of AMER (Association of Malaysian Environment-Behaviour Researchers) and cE-Bs (Centre for Environment- Behaviour Studies, Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Malaysia.
doi:10.1016/j.sbspro.2016.05.191

1. Introduction

Industrialised Building System Modular System (IBSMS) is the rebranding of modular construction to suit and adapt to the IBS approach in the Malaysian construction industry. IBSMS is a process to construct a building using modular or three-dimensional units; mass produce offsite in a manufacturing facility that highlighted the importance of design, manufacturing and construction elements in the process. These modular units are mass produced using the same materials and design to the same standards that increase the construction speed. It includes the assembly and logistic aspect of it done in proper coordination through detailed planning and integration (Musa, et al., 2014). The implementation of modular construction is proven to improve productivity, economically and promotes sustainability of the construction industry.

Modular construction is classified as off-site prefabrication and modern method of construction and used in developed countries such as US, UK, Japan and Australia due to its benefits. Thus, it is essential for the Malaysian construction players to be well prepared and ready to implement modular construction since Malaysia is moving towards achieving develop country status. Industrialised Building System (IBS) is the terminology to represent the prefabrication concept in the Malaysian construction industry. The move to introduce modular construction is to be expected because of modular construction's features to eliminate IBS limitation. Since IBS is already established in Malaysia, thus it is essential for modular construction to adapt IBS approach to ensure the effectiveness of modular construction implementation in the Malaysian construction industry.

Modular construction and IBS promotes sustainability in the construction environment that will develop and enhance the quality of life (Mohammad, 2013; Musa, Mohammad, Mahbub & Yusof, 2014), Modular construction and IBS contributes to sustainability by reducing damages to the environment, improve social relationship amongst the construction players and contribute to economic sustainability. Modular construction enhances the quality of construction products, reduces wastage and reduces the project duration. Thus, it is essential that modular construction and IBS to be well implemented and executed so that it can contribute to the enhancement of the quality of life. Therefore, through strategic planning, IBSMS organisational readiness framework needs to be developed to ensure the efficient implementation of modular construction and IBSMS in the Malaysian construction industry. IBSMS and modular construction will be introduced in the Malaysian construction industry by Construction Industry Development Board (CIDB). Hence, it makes this study and framework essential to the future development of the Malaysian construction industry.

Although the advantages and potential of modular construction are well documented, the implementation and execution process requires appropriate strategic planning to realise the potential of modular construction. One part of the strategic planning is to outline the readiness criteria or variable needed for an organisation to execute or adopt modular construction. It is crucial for an organisation or people in the organisation to be well prepared and ready to implement modular construction, to ensure the efficient delivery of modular construction.

2. Literature review

IBS is the terminology to represent prefabrication concept in the Malaysian construction industry. IBS introduced in Malaysia since the 1960s mainly to speed up construction projects and reduce the usage of foreign workers working in the Malaysian construction industry. Thus, the government has promoted the use of IBS through government projects whereby 70% IBS usage in a government project. IBS is a construction process that uses standardised building components mass produce in a factory or site then transported and assembled into a structure using appropriate machinery and equipment with minimal workers with proper planning and integration (Musa, Mohammad, Yusof & Mahbub, 2015). In the other hand, modular construction is a worldwide off-site prefabrication or manufacturing of 3-dimensional units' concept. Modular construction was developed since the 1940's, during the World War 2 as a solution for the soldier's accommodation. Modular construction is a construction method to produce a building using three-dimensional modular units or modules, mass produce off-site in a manufacturing facility. It includes the logistic and assembly of it, done in proper coordination with through planning and integration (Musa, Yusof, Mohammad & Mahbub, 2014). Even though, modular construction is well established globally, but it is essential for modular construction to adapt to IBS approach. It is to ensure the efficiency of modular construction implementation and delivery in the Malaysian construction industry.

2.1. The concept of readiness assessment

Readiness assessment refers to a managerial assessment tool to evaluate the readiness gap of the organisation prior to the asset, capital, human resource and investment. It identifies the current capability of the organisation as compared to the targeted level that an organisation would want to achieve. The organisational capability is a strategic application of competencies (Kangas, 1999). Organisational capability is the development and deployments of particular organisational competencies that are the processes of building the organisational capability (Alshawi, 2007). Meanwhile, the term competency refers to the organisational capacity and ability to deploy resources, usually in combination, using organisational processes, to achieve specific objectives (Amit & Schoemaker, 1993). Competency represents a bundle of interrelated skills and technologies (Peppard & Ward, 2004). Competence is therefore portrayed as the ability to deploy combinations of organisational-specific resources to accomplish a given task (McGrath, MacMillan & Venkatraman, 1995).

By referring to Figure 1, performance level identifies the current status of the business function in terms of the pre-identified evaluation criteria, while the target performance level identifies the desirable situation for this particular business function and is measured by the same evaluation criteria. The difference in the value of the evaluation criteria between the current and the target performance level is known as the opportunity gap. The information that this gap can provide is:

- Focus and guidance in the area for improvement by providing information on which areas are critical and which are not, so the resource can be prioritised;
- The level of change to successfully implement modular construction and IBSMS.

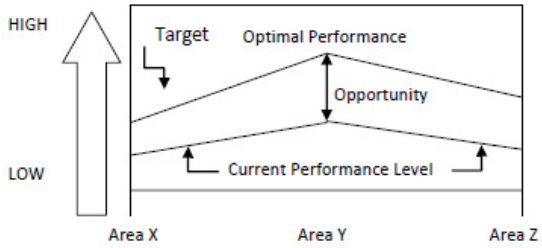

Fig. 1. Performance analysis chart (Alshawi, 2007)

2.2. Reviewed readiness assessment frameworks

In developing the framework used for this research, selected readiness frameworks and models were reviewed as can be seen in Table 1. The focus was given to determine the elements, categories and criteria of the framework where pattern matching technique was used. The selection and adoption of each type were made based on the following criteria:

- The appropriateness of the category to be used within the framework of the organisation;
- The suitability of the type to be used specifically in the framework of the modular construction and IBSMS implementation.

Table 1. Summary, literature review and comparison of readiness assessment model and framework

Model/ Criteria/ Framework	CMMI (Software Engineering Institute, 2014)	SPICE (Alshawi, 2007)	Verdict (Ruikar, 2006)	BEACON (Khalfan, 2001)	BIM Readiness Framework (Haron, 2013)
Description and the usage	• Capability Maturity Model Integrated consists of best	• Standardised Process Improvement for	• Verify End-User e-Readiness is an e-readiness model that	• Benchmarking Readiness Assessment for Concurrent	• Building Information Modelling

	practice that can be used to improve the process within a project, a division, or organisation.	Construction Enterprises is a systematic step by step process improvement framework for the construction industry.	assesses the readiness of the organisation to adopt e-commerce tools, such as web-based collaboration tools.	Engineering is a concurrent engineering readiness assessment model.	Readiness Framework is a readiness assessment to assist the design consultant to identify the readiness gap of the company to adopt BIM.
	• The assessment is looking for the maturity and capability of the process, and it has five maturities and six capability level three models available.	• Consist of 5 level of maturity based on the presence of key process in each level.	• Consist of 3 level of readiness Red= Critical, Amber=less critical, Green=e-ready.	• Adapted from Readiness Assessment for Concurrent Engineering Model (RACE), which is used in manufacturing.	• Consists of 4 Readiness Elements that are People, Management, Technology and Process.
	• The model concentrates on Product and service development, Service establishment, management, and delivery and Product and service acquisition.	• The assessment is carried out by determining the implementation of critical process by the organisation.	• Can be used to evaluate the E-readiness of construction companies, department (s) within a business or even individual work groups within a department.	• Consist of 5 level maturities that are Ad-hoc, repeatable, characterised, managed and optimising. • It is conducted before the introduction of CE within an organisation.	
Key Element, Category and Readiness Criteria	Initial Managed -Requirements Management -Project Planning -Project Monitoring and Control -Supplier Agreement Management -Measurement and Analysis -Process and Product Quality Assurance -Configuration Management	Initial Planned and Tracked -Brief and scope of work management -Project Planning -Project Tracking and Monitoring -Subcontract Management -Project Change Management -Health and Safety Management -Risk Management -Project Team Coordination	People -Head of Process (Change Management) -Role and Responsibilities -Work environment -Culture -People Capability	Process -Management Systems -Process Focus Organisational -Arrangement -Strategy -Deployment -Agility	Process -Process Change Strategy -BIM Implementation Management -Policy
	Defined -Requirements Development -Technical Solution -Product Integration -Verification -Validation -Organisational process focus -Organisational Process Definition -Organisational training	Well defined -Organisation Process Definition -Organisation Process Focus -Integrated Design and Construction Management -Construction Life Cycle Engineering -Training Programme Peer	Management (top level) -Strategy -Support and Commitment -Awareness -Performance Measure	Technology -Task Support -Integration -Support -Information Sharing -Coordination Support -Communication Support	People -Roles and Responsibilities -Skill and Attitude -Training and Education -Work Environment

	-Integrated Project Management -Risk Management -Decision Analysis and Resolution	Reviews			
	Quantitatively Managed -Organisational Process Performance -Quantitative Project Management	Quantitatively Controlled -Quality Management -Quantitatively Process Management	Process -Business process -Client -The use of e-commerce tool in process	People -Teams in an Organisation -Discipline -Team leadership and Management -Team Formation and Development	Management -Business Strategy -Management Competency -Leadership
	Optimising -Organisational Innovation and Deployment -Causal Analysis and Resolution	Continuously Improving -Process Change Management (CM) -Technology CM -Defect Prevention	Technology -System -Infrastructure -IT Policy	Project -Facility Design -Quality Assurance -Client Focus	Technology -Hardware -Software -Technical Support
Status	Commercial	Research Prototype	Research Prototype	Research Prototype	Research Prototype
Can be used for IBSMS?	Yes, but particular modification is required before applying it to assess IBSMS readiness in the organisation.	Yes, but the focus is limited to the process improvement only	Yes, but particular modification is required before applying it to assess IBSMS readiness in the organisation.	Yes, but significant modification is needed before applying it to assess IBSMS since the primary focus is on CE.	Yes, but modification is required before applying it to assess IBSMS.

3. Research methodology

At first, the research's aim was to develop and validate an organisational IBSMS readiness framework for IBSMS contractor and manufacturer in Malaysia. The methodology was literature review and interview sessions with representatives from the modular system and IBS manufacturers in Malaysia. There are three modular system manufacturers/contractors and one IBS manufacturer selected for the study. Since, modular construction is new in Malaysia. Thus, it is hard to search for modular system manufacturers. The developed framework developed from the interview sessions and literature review is then validated by a panel of selected by CIDB IBS Centre. The panel is representatives from Ministry of Urban Wellbeing, Housing and Local Government, Ministry of Works, PR1MA and CIDB officers. After the first validation meeting, the panels agreed that the framework should cover the whole of the Malaysian construction industry.

Thus, a questionnaire survey was added to the methodology of the framework. The approved questionnaire surveys were distributed during an IBS seminar organised by CIDB and Universiti Teknologi MARA (UiTM) held in Grand Blue Wave Hotel, Shah Alam on the 22nd April 2014. IBS practitioners such as developers, IBS manufacturers, IBS contractors, IBS consultants, academicians and others attended the seminar. The questionnaire survey was answered by 63 respondents who attended the seminar. Data collected from the questionnaire survey is analysed and the findings are added to the final framework. The final readiness framework is validated by the same panel selected previously by CIDB IBS Centre and additional representatives from the academicians and end user. The academician representatives are from UiTM and random end user. Since the readiness framework covers academician and end user perspective, it is essential that the validating panel has academician and end user representative.

4. The IBSMS organisational readiness framework

This study focuses to develop and validate an organisational readiness framework for all the construction industry players, professional and stakeholder to adopt and implement IBSMS and modular construction in Malaysia. The first objective of the framework is to identify the requirements and capability needed for an organisation to use or adopt modular construction and IBSMS. The second goal is to validate the framework. The framework outlines the readiness elements and criteria. Each of the criteria describes the requirement and capability that an organisation requires to develop or must have to deliver a better and efficient IBSMS and modular construction application. The framework can be used for all the construction industry organisations or players who want to adopt and use IBSMS or modular construction.

The 1st proposed readiness framework is developed from the data collected through literature review and interview sessions. The framework was to cater the readiness criteria for IBSMS's contractor and manufacturer. The framework consists of five elements that are people, process, technology, cost and management, and each element consists of readiness criteria. In the framework, the elements of people, process, and technology are proposed and justified by the importance of the three components for successful implementation of technologies. Ruikar, Anumba, & Carrillo introduced a management element to their Verdict model justifying the role of management to coordinate and manage the implementation of e-commerce (Ruikar, Anumba, & Carrillo, 2006). To successfully implement and use any new technology, management buy-in and belief is required, to plan and drive policies and strategies (Smith & Tardif, 2009).The execution requires total commitment from the management to lead the top down approach to implement IBSMS, provide adequate support and resources, and to align IBSMS implementation strategically with business needs. The authority to direct orders and make decisions also strengthens the need for the management category to be included. According to Kamaruddin, Mohammad & Mahbub (2014) and data collected from the interview sessions with experts in modular construction, cost or financial element are essential to the introduction of a new technology in an organisation. All other elements such as people, technology, management and process will involve cost and money.

For the readiness framework to covers additional construction industry players that includes client, end user, government authorities and others based on the request of the validation panel, a questionnaire survey was used for additional data collection. Analysed data and findings from the questionnaire survey was added to the 1st proposed framework. The factory is the new readiness element added to the framework. Since modular units or modules used in modular construction are totally off-site productions, the factory element is essential for IBSMS and modular construction. The new readiness criteria are also added to the framework. Under the Cost Element, new readiness criteria are added such as the cost of the factory, the cost of transportation, the cost of material and cost of the human resource. For technology readiness element, logistics and transportation, material selection and R&D is added to the criteria. Figure 2 is the finalised and validated IBSMS organisational readiness framework.

Furthermore; new feature coding is added to the new framework used to differentiate construction industry player's readiness requirements as shown in Table 2. For example, a contractor would like to adopt modular construction; they must fulfil the readiness criteria outlined in the people, management, process, cost and technology elements. For the modular unit manufacturer, it must fulfil all the criteria set out in all the components of the framework. Failure to fulfil all the readiness criteria does not mean the organisation cannot implement or execute IBSMS and modular construction. The organisation can implement modular construction and IBSMS, but they will face a few hiccups and setbacks along the way.

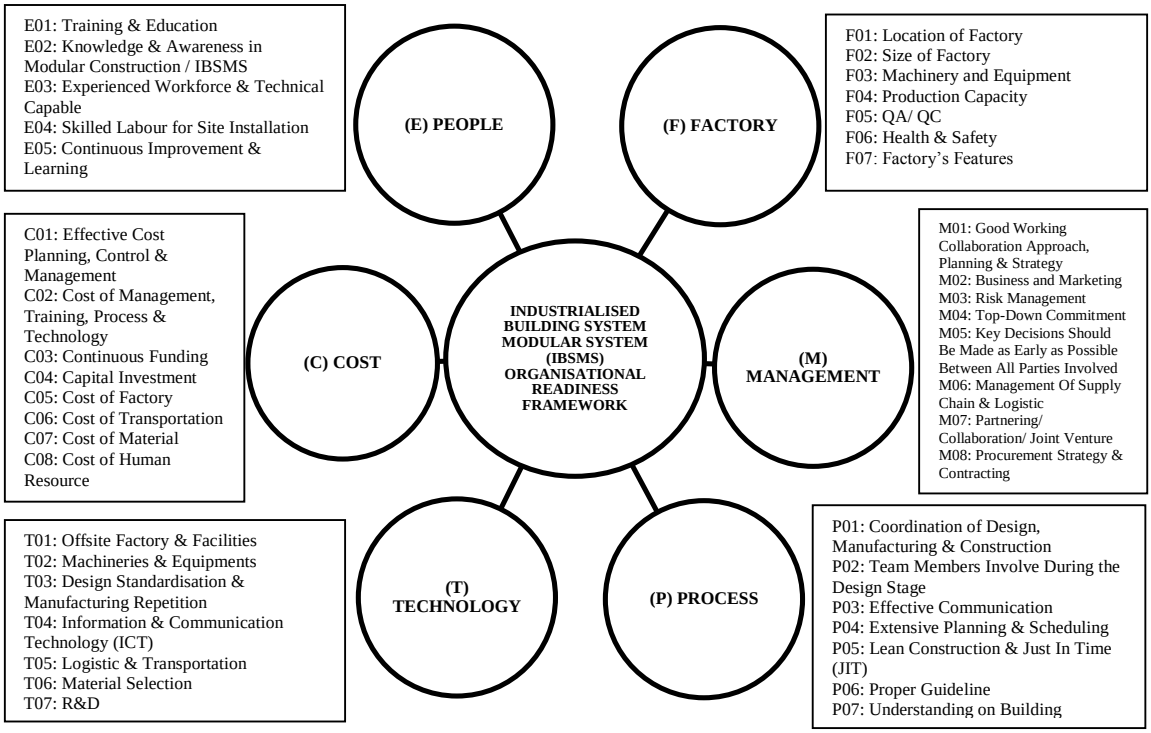

Fig. 2. The IBSMS organisational readiness framework

Table 2. Readiness elements for the respective construction industry players

Construction industry players and stakeholders	Readiness elements
Client, End User & Academician	People (E)
Government, Authority & Local Council	People (E), Process (P), Technology (T)
Developer, Contractor, Consultant, Installer & Transporter	People (E), Cost (C), Management (M), Process (P), Technology (T)
IBSMS/ modular unit manufacturer and Material Supplier	Factory (F), People (E), Cost (C), Management (M), Process (P), Technology (T)

5. Discussion

Table 3 has outlined the readiness elements, criteria and descriptions in the IBSMS Organisational Framework. There are six readiness elements in the readiness framework that are Factory (F), People (E), Cost (C), Management (M), Process (P) and Technology (T). All six readiness elements have it own readiness criteria. For example, Factory (F) readiness element has seven (7) readiness criteria such as Location of Factory (F01), Size of Factory (F02), Machineries and Equipments (F03), Production Capacity (F04), QA/ QC (F05), Health & Safety (F06) and Factory's Features (F07). The descriptions for every readiness elements and criteria are in Table 3.

Table 3. Readiness elements, readiness criteria and the readiness criteria's descriptions of the IBSMS organisational readiness framework

Readiness elements	Readiness criteria	Descriptions
People (E)	E01: Training & Education	Training & education in modular construction/ IBSMS.
Experience and knowledge workers in IBSMS and	E02: Knowledge & Awareness in Modular Construction / IBSMS	Knowledge & awareness about modular construction / IBSMS for the individuals, organisation and others.

modular construction are needed to produce and operate IBSMS and modular construction. Continuous development and training for the people involved in the organisation.	E03: Experienced Workforce & Technical Capable	The availability of experienced workforce & technical capable of modular construction or offsite construction.
	E04: Skilled Labour for Site Installation	Skilled and competent labour in modular construction for site installation or on-site is necessary.
	E05: Continuous Improvement & Learning	Continuous improvement & learning about modular construction/ IBSMS through the training programme.
Cost (C)	C01: Effective Cost Planning, Control & Management	Effective cost planning, control & management for the modular construction project is crucial.
The organisation must have the sufficient fund and financial ability to produce and execute IBSMS and modular construction	C02: Cost of Management, Training, Process & Technology	The cost of management, training, process & technology to adopt modular construction/ IBSMS.
	C03: Continuous Funding	Continuous funding for the operation and execution of the organisation adopting modular construction.
	C04: Capital Investment	A solid capital investment to adopt modular construction/ IBSMS is required.
	C05: Cost of Factory	The overall cost to build a factory producing modular units or modules needs to be considered.
	C06: Cost of Transportation	The cost to transport the modules from the factory to the construction site needs to be accounted.
	C07: Cost of Material	The cost of the material used to produce a modular unit or modules example aluminum, steel and others.
	C08: Cost of Human Resource	The cost to hire, train and maintain the workers is also essential.
Technology (T)	T01: Offsite Factory & Facilities	Offsite factory and facilities capable of producing modular units is essential since all the modular units are built off-site.
Technology to produce and execute IBSMS and modular construction is critical to lifting and assemble the modular units or modules. The technology needed to be up to date and upgraded base to the technology advancement in the construction industry	T02: Machineries & Equipment	Machineries & Equipment to produce and install modular units in the factory and on-site.
	T03: Design Standardisation & Manufacturing Repetition	Design standardisation amongst the modular units manufacturer is crucial to encourage an open system& manufacturing repetition suitable for modular units.
	T04: Information & Communication Technology (ICT)	The use of Information & Communications Technology (ICT) to enhance modular construction such as Building Information Modeling (BIM).
	T05: Logistic & Transportation	It is essential that during the transportation follow the road/ highway regulation set by every country. New transportation technology must also follow the road law and suitable to be used.
	T06: Material Selection	Material selection affects the cost, design and construction method of the modular units.
	T07: Research and Development (R&D)	Continuous R&D is required to ensure improved and innovative modular units are produced.
Process (P)	P01: Coordination of Design, Manufacturing & Construction	Coordination of design, manufacturing & construction in a modular construction project from the beginning of the project. For an off-site prefabrication, design, manufacturing and construction factors are essential.
For an organisation to execute and operate IBSMS and modular construction, it must have a profound understanding of the IBSMS and modular construction overall process	P02: Team Members Involve During the Design Stage	Team members (client, consultants, manufacturer, and contractor) must involve during the design phase of a modular construction project to avoid problems later in the project.
	P03: Effective Communication	Effective communication amongst team members (client, consultants, manufacturer, contractor) in modular construction project to ensure no miscommunication

		amongst team members.
	P04: Extensive Planning & Scheduling	Extensive planning & scheduling for a modular construction project. Since modular construction has a factory element, thus a detailed scheduling is required to ensure precise production of modular units.
	P05: Lean Construction & Just In Time (JIT)	Lean construction & Just In Time (JIT) concept needs to be applied in a modular construction project.
	P06: Proper Guideline	Proper guideline for modular construction is essential to ensure the smooth delivery process.
	P07: Understanding on Building Regulations	Every country has it own building regulations. Thus, it is essential to ensure the modular units follow the building regulations.
Management (M) Management of the organisation is essential to guide the direction of an organisation. For an organisation able to produce and execute IBSMS and modular construction.	M01: Good Working Collaboration Approach, Planning & Strategy	Good working collaboration is a must amongst team members (client, consultants, manufacturer, and contractor) in modular construction project.
	M02: Business and Marketing	A proper business and marketing approach, through planning & strategy that is suitable for the modular construction business.
	M03: Risk Management	Organisation needs to establish a risk management for a modular construction project.
	M04: Top-Down Commitment	Top-down commitment from the organisation (The top management to general labours need to work as a team and work together to execute IBSMS).
	M05: Key Decisions should be Made as Early as Possible Between All Parties Involved	Key decisions should be done as soon as possible between all parties (client, consultants, manufacturer, contractor, and supplier) involved in the modular construction project.
	M06: Management of Supply Chain & Logistic	Organisation needs to manage supply chain & logistic for a modular construction project.
	M07: Partnering/ Collaboration/ Joint Venture	Organisation needs to partner/ collaboration/ joint venture in modular construction with other organisation involve in IBSMS.
	M08: Procurement Strategy & Contracting	To have procurement strategy & contract suitable to be used in a modular construction project.
Factory (F) For modular construction and IBSMS, the factory is essential since the modular units or modules are totally off-site prefabrication in the factory. The modular units cannot produce and prefabricate on-site.	F01: Location of Factory	The location of the factory can affect the cost and transportation factor. There are cases, whereby since the cost of labour is expensive compared to the cost of transportation; the manufacturer chooses to build their factory oversea.
	F02: Size of Factory	The size of the factory will affect the production of the modular units and the overhead cost bare by the manufacturer. The size of the factory includes the store to keep the materials and modular units.
	F03: Machinery and Equipment	Machinery will ensure higher productivity rate compared to manpower. Gantry crane is necessary for long productivity line.
	F04: Production Capacity	Production capacity will depend on the machinery, equipment, size and feature of the factory. The better the machinery and bigger size of the factory, the higher production capacity of modular units can produce by the factory.
	F05: QA/ QC	Quality Assessment and Quality Control is essential to delivers high-quality modular units.
	F06: Health & Safety	The factory will be able to provide better health and safety

	to the workers compare to on-site.
F07: Factory's Features	Characteristics of a factory will affect the cost to build a factory. A full closed factory is expensive compared to a half closed and open factory.

6. Recommendations and conclusion

For future research, organisational readiness frameworks for other IBS systems can be developed in the future. There are six IBS systems that yet to have readiness framework. It is essential to developed readiness framework for the other IBS in Malaysia to encourage more IBS practitioners and efficient IBS delivery, execution and implementation. Furthermore, a study to assess the readiness of the Malaysian construction industry organisations to adopt modular construction or IBSMS based on the variables in the established framework can be carried out in the future. There is the need for the Malaysian construction industry to opt for a new and improved construction technique, to shift from the conventional construction to the modern method of construction and sustainable construction approach. The established IBSMS Organisational Readiness Framework hope to improve the Malaysian construction industry through efficient delivery and better readiness for an organisation that wants to implement and execute modular construction and IBSMS in the Malaysian construction industry.

Acknowledgements

The Authors wish to thank the Construction Industry Development Board (CIDB), Universiti Teknologi MARA (UiTM) and a remark of indebtedness to the Acculturation Grant Scheme (RAGS) by the Ministry of Education, Malaysia for its grant award (600-RMI/RAGS 5/3 (189/2013)).

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